Professors of Physics at different Universities have usually selected their best students to assist them in their private laboratories, to the mutual advantage of professor and student, but I believe that Prof. Clifton was the first to propose, more than three years ago, that a course of training in a physical laboratory should form a part of the regular work of every student of Physics.

This system was adopted and at once put in action at King's College, on a very considerable scale for a college with no endowment whatever, and has been working for now nearly three years. Two large rooms adjoining the Museum of Physical Apparatus were fitted up for a Physical Laboratory, and a third room was built for a store and battery room. Fixed tables in both large rooms are supplied with water and gas, and with pipes passing to gasholders containing oxygen and hydrogen, also with thick copper wires insulated from one another passing to the battery room, so that in electrical work the fumes from batteries are entirely got rid of.

The principal instruments have their fixed places on the tables, and a description of the measurement to be made is given to each student, and while in progress his work is examined by the professor or demonstrator. The course of study includes the subjects of pneumatics, heat, light, electricity, and magnetism, and with the regular class, a definite order in each subject is kept to as nearly as possible. When, as has sometimes been the case, there are twelve or more students beginning their laboratory course at the same time, it is necessary to deviate from the regular course, and to set some to begin with heat, some with light, and others with electricity. For some experiments, such as the determination of the relation between the pressure and volume of a gas, or the measurement of the expansion of a gas for given changes of temperature, requiring the use of the manometer and cathetometer, it is found better to have two students working together, each student making in his turn and so checking every part of the measurement or determination.

The accuracy of the results obtained has been very great, and is an evidence of the interest taken in the work by the student, and of the value of such a course of study as a mental training, to say nothing of the actual knowledge gained. Every student is required to produce fair results, and to give an account of the methods which he has employed, before he is allowed to proceed to another part of the subject. Besides the students pursuing the regular course there are several who wish to devote their attention to some one branch, such as Electricity. In this subject, after making determinations of Resistance, Strength of current, and Electromotive force with simple galvanometers, they pass to more delicate measurements with Thomson's Galvanometers and Electrometers, such as the experimental determination of equi-potential lines on a conducting surface uniting two poles of a battery, and perform all the tests and measurements required in connection with Telegraph lines and cables.

The more advanced students carry on investigations in the Laboratory, such as the measurement of the effect of heat in altering the magnetic polarity of dia-magnetic bodies, or in altering the rotation of the plane of polarisation of a beam of polarised light as it passes through sugar solutions.

Students are encouraged to combine their work in the Physical Laboratory with their work in the Mechanical Workshop, and are enabled to design and construct apparatus, and their inventive powers are exercised often with great success. From experiments with Attwood's Machine one student has designed and made for himself a new form of governor for an engine, another has designed an Inductometer for measuring the time required to produce the maximum induced current in a wire by the action of another current.

The success of the Laboratory system of teaching may be judged from the quality of the work done by the students, who are mostly from sixteen to eighteen years of age, and are always eager for the work, as well as from the fact that in the last term there were twenty-three students in the Laboratory, and the numbers are steadily increasing.

It will be seen that to the student of Electricity or any branch of Physics, every opportunity is offered of pursuing the object which lies before him, and that the advance which may be made by him is dependent only on his own exertions. W. G. ADAMS

MORELL'S GEOMETRY

The Essentials of Geometry, Plane and Solid, as taught in French and German Schools, with shorter Demonstrations than in Euclid; adapted for Students preparing for Examination, Cadets in Military and Naval Schools, Technical Classes, &c. By J. R. Morell, formerly one of Her Majesty's Inspectors of Schools. (London: Griffith and Farran, 1871.)

A WORK with this attractive and somewhat ambitious title cannot fail to attract attention, appearing, as it does, at a moment when very commendable efforts are being made to improve the teaching of Geometry in our schools, and to prepare the public mind for an important reform which will necessarily involve the adoption of text-books more suited to modern habits of thought and inquiry than the Elements of Euclid. It will, no doubt, therefore be expectantly read by many, and the fact that the author is already widely known as a writer on philosophy and grammar, and was formerly one of Her Majesty's Inspectors of Schools, will tend to raise expectations, and will lend it an authority to which, as we shall presently see, it is by no means entitled. Our duty to students preparing for examination compels us, in fact, to warn them that this book can render them no essential service whatever, but, on the contrary, may do them incalculable mischief; and our sympathy with the praiseworthy efforts above alluded to—our desire to prevent undeserved discredit from being attached to those efforts—obliges us to dissociate this one from them, and to criticise it with all due severity.

The plan and general arrangement of the book are open to the severest criticism; we deem it unnecessary, however, to dwell thereon, for the work is so destitute of the most essential of all "Essentials of Geometry"—accuracy and clearness—that no possible rearrangement of its materials could redeem it. We shall consequently draw attention solely to the deplorable looseness of expression, indicative of hopeless inaccuracy of thought with which almost every page is disfigured.

We shall commence with quoting a few definitions, and simply italicising their most salient incongruities. Further comment will rarely be needed.

"Extension is the *space* occupied by a body" (p. 1).

"A straight line is that which has all its *points* in the same *direction*" (p. 1). Direction is, of course, not defined, nor is it stated whence the points of the line are supposed to be viewed.

"A plane angle is the *greater* or *less* inclination of two straight lines *to a common point*" (p. 5). In a note hereto the author complacently observes that "our definition accords with Euclid, Bk. i., n. 8."

"The angle A O B increases continually *in proportion* as the straight line O B takes the direction O C, O D, &c." (p. 6).

"The name adjacent angles is given to those angles that have one side common" (p. 6). The author appears to have felt that there was some insufficiency here, but instead of expunging the passage as wholly useless, he tries again in small print, and almost, though not quite, succeeds. That some haziness still clings around his conception of adjacent angles is obvious; for when we come, in the Geometry of Space, to angles between two planes, dihedral angles, we are told (p. 90) that "adjacent dihedral angles are those which have a common plane, *and whose other two sides are in one plane*." The condition here italicised is wholly unessential, and the really essential one is again omitted; viz., that the two angles should be on opposite sides of their common plane. This misconception of the nature of adjacent dihedral angles leads the author, naturally, to the following absolutely false definition:—"If two adjacent dihedral angles are equal, each one is named a dihedral right angle." We may here observe that there is deplorable confusion in this part of the work between polyhedra and polyhedral angles. Trihedral angles are generally, though not always, termed *trihedra*, dihedral angles occasionally crop up as *dihedra*, and uncouth entities such as *polyhedrals*, *dihedral sides* of a polyhedral angle (p. 94), and *polyhedral triangles* (p. 95), not unfrequently stop the way.

Leaving definitions, however, let us glance at Mr. Morell's enunciations of theorems, and the "improved shorter demonstrations" of them with which he supplies us.

On p. 3 we find the following short paragraph, into which a theorem and its demonstration are supposed to be condensed:—"Any diameter whatever divides a circumference into two equal parts; *therefore* if on superposing its two halves they did not agree, the radii of the same circumference would be unequal, which is absurd." The word *therefore* would imply that the assertion which precedes it is not itself the theorem to be demonstrated, but one which is to be employed in demonstrating something else. But what is this something else? Long reflection failed to furnish any answer to the question; it seemed but to give to the last three words a more extended significance than the author could have contemplated.

The entire paragraph remained a mystery to us, in fact, until we reached p. 25, when Mr. Morell's happy arrangement enabled him to return to the subject in these slightly modified words:—"Every diameter divides the circumference into two equal parts; *for* if on placing one *half* on the other they did not coincide, the radii of one and the same circumference would be different in length, which is absurd." Here the word *for* being substituted for *therefore*, we can no longer doubt that what precedes it *is* the theorem to be proved; the moment one *part*, however, is termed a *half* the whole question is begged; and even if this gross blunder had been avoided, the demonstration would still have been worthless, so long as the *mode* of placing one part on the other was left wholly unexplained.

The enunciation and demonstration of the two fundamental theorems of parallels are thus given on p. 21:—

"If two straight lines are parallel, and are cut by a secant, the alternate angles are equal, and also the corresponding angles. Conversely, if two straight lines cut by another form equal alternate or corresponding angles, the said lines will be parallel."

"For two alternate internal, or alternate external, or corresponding angles are both either acute or obtuse, and *consequently* equal in the case of parallels. But, if of two internal or external angles on the same side, one is acute, and the other obtuse, these angles are, *therefore*, supplementary."

Let the reader picture to himself for a moment the perplexity of the misguided student, "preparing for his examination," as he vainly strives to extract a meaning from this sheer nonsense. Distrustful of his own powers, the poor fellow will probably attribute his failure to his own incapacity, and in despair commit the precious passage to memory for the purpose of reproduction when his hour of trial shall come. The consequences of such rashness need not be stated. And yet Mr. Morell cites a respectable French geometer as an authority for this "shorter demonstration!" It was with no small curiosity that we turned to the pages of Amiot's *Éléments de Géometrie* to see how an author, who usually writes with admirable clearness, though not always with desirable rigour, could have been made responsible for such absurdity. The process was simpler than we expected; editorial scissors had simply clipped away everything worthy of the name of demonstration, and the editorial pen had garbled the feeble residue into the chaotic sentences above reproduced. We know of no epithet too severe to apply to editorial transgression of the kind here exposed.

To proceed with the painful task we have imposed upon ourselves, we have next to draw attention to two blunders, not in geometry, but in simple logic. On p. 20 we read as follows:—

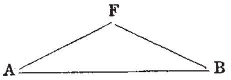
"It is often assumed as a self-evident proposition that through a given point only one parallel can be drawn to a straight line," and, in a foot-note hereto, we are told that "this is the *opposite* of Euclid's 12th axiom, similarly assumed to base upon it his theory of parallels." Had Mr. Morell read Amiot, even, with anything like attention he would have seen that this is not the case. In forming the opposite of a theorem, the new hypothesis and predicate must be made to contradict, respectively, the original hypothesis and predicate. The opposite of Euclid's 12th axiom, therefore, as Mr. Morell may now convince himself by trial, is very different from the one above quoted.

On p. 44 again, we have this marvellously short enunciation and demonstration of Euclid's Prop. 8, Book I.; "Let A B C, D E F be two triangles, having A B = DE

A C = D F, and B C = E F. Then angle A = D ; *for if they were unequal, sides B C and E F would be unequal. Therefore* A = D." In violation of the most obvious of all logical rules, Mr. Morell here professes to prove a theorem by the simple assertion of it in its contra-positive form ! To assert that B C and E F would be unequal if A and D were unequal is *logically equivalent* to saying that A and D would be equal if B C and E F were equal, which is precisely the proposition to be proved. The truth of either of these statements involves that of the other by the necessary laws of thought, and neither can be said to require geometrical demonstration more than the other. It is true that Euclid himself (*vide* Props. 7 and 9, Book iii.) overlooked this necessary relation between contra-positive theorems. But Euclid's error was very trivial in comparison with Mr. Morell's. Euclid proved *both* theorems geometrically when a proof of one would have sufficed, but Mr. Morell unwarrantably *asserts* the truth of one, and imagines he has thereby proved the other.

Notwithstanding the fact that Mr. Morell devotes a considerable part of his book to the approximate calculation of the ratio of the circumference of a circle to its diameter, we fear that he must henceforth be classed amongst the "circle squarers of the period." For, as is well known, the solution of this vexed problem is at once reducible to that of the rectification of the circumference ; and on page 62 we find it stated that "the graphic construction which *gives us the length of the circumference in a straight line* is the following." For obvious reasons we forbear to reproduce it.

The "technical classes" to whom Mr. Morell professes to have "adapted" his text-book, will, we fear, derive as little profit from its pages as the "students preparing for examination." How can it profit them, for instance, to be told that "many public buildings have as façade a front elevation like A F B?" Yet it is with this *isolated* technical observation that Mr. Morell terminates the forty-first page of his book. Again, what earthly, not to say technical use can they make of the three very bad pictures of a surveying rod, a Gunter's chain, and a measuring tape, with which they are favoured on page 36? On page 37, Mr. Morell starts with his technical class to determine a straight line through "a winding narrow street ;" but he fails utterly to bring them round the very first corner. On page 38 he proposes to show them how "to draw *a* perpendicular bisector of a given straight line in nature," but we will not disfigure this page of NATURE with a reproduction of his unintelligible method. Although readers might be amused by it, we are not in a humour to extract amusement from a work which was certainly not written for the purpose of providing it, but with the serious intention of teaching Geometry in an improved manner.



We have by no means exhausted the incongruities of the book ; but we have, we think, sufficiently shown that the teaching of Geometry cannot but be vitiated by its use ; that, in fact, this text-book of Her Majesty's ex-Inspector of Schools will itself bear no inspection whatever.

RODWELL'S DICTIONARY OF SCIENCE

A Dictionary of Science : comprising Astronomy, Chemistry, Dynamics, Electricity, Heat, Hydrodynamics, Hydrostatics, Light, Magnetism, Mechanics, Meteorology, Pneumatics, Sound, and Statics. Edited by G. F. Rodwell, F.R.A.S., F.C.S. (London : E. Moxon and Co., 1871.)

THERE are Dictionaries and Dictionaries. We have had occasion to expose the shortcomings of some books that are called by this name ; it is a far pleasanter task to direct attention to the merits of a work like the one before us, which really deserves its title. Mr. Rodwell's "Dictionary of Science" is a repertory of facts connected with physical science, which will be invaluable to the student. From Chemistry to Chladni's Figures ; from Thermo-dynamics to Turacine, scarcely a term will be met with in scientific works, of which the learner will not here find an explanation. The articles have the great advantage of being short, and presenting the salient points of each subject at a glance before the reader's eye ; and that their scientific accuracy may be relied on, is guaranteed by such names (amongst others) as those of Mr. Crookes, Prof. Guthrie, and Mr. Wormell in the list of contributors. To illustrate the style of the book, we cannot do better than select two of the shorter articles. The first is on a subject which has recently been discussed in these columns :—

"*Mass.*—Mass is a term for the quantity of matter in a body. In order to measure mass, we assume that the attraction of the earth on all particles of matter is the same, and is not dependent on the nature of the matter attracted. This assumption seems to be justified by the fact that bodies of all kinds fall with equal velocity in the exhausted receiver of an air-pump. Hence we measure the mass of a body by its weight, and can only define the mass as a quantity proportional to the weight. If, then, at the same spot of the earth's surface, one body is twice as heavy as another, the mass of the first is twice that of the second. Suppose, however, that the body be weighed by a spring-balance at a certain place, and weighed again by the same instrument at another place nearer the equator, it will be found that the body is lighter at the latter place. It is found also that the acceleration due to the attraction of the earth is also less at the second place than at the first, in the same proportion. This illustrates the fact that when the mass remains the same, the weight varies as the acceleration of gravity. Hence the weight varies as the product of the mass and the acceleration of gravity, and, consequently, when suitable units are chosen, the mass of a body is equal to its weight divided by the acceleration due to gravity."

Our next extract is chemical :—

"*Alcohol.*—By this name, when standing by itself, is usually understood the second term of the series of ordinary alcohols, or vinic alcohol. It is a transparent, colourless, mobile liquid, of a specific gravity 0·7939 at 60° F.; it boils at 74·4°C. (173·1 F.) ; its vapour density is 1·613 ; its formula is $C_2 H_6 O$; it is the spirituous principle of wine, beer, and spirits, and is produced by the fermentation of sugar, which is split up into alcohol and carbonic acid. In the diluted state alcohol is sometimes called spirits of wine. It is difficult to render anhydrous ; distillation alone will not produce an alcohol containing less than 9 per cent. of water, and this remaining quantity must be removed by adding something which unites with the water chemically, as quick-lime. By oxidation it is converted into aldehyde, and then into